

Claims

1. Method for producing a three-dimensional multi-material component by the ink-jet-type printing of droplets of at least one material in successive layers, characterised in that it comprises at least the stages consisting of:

(1) cutting up a representation of the multi-material component into characteristic objects;

(2) slicing the representation of the component into print layers as a function of said characteristic objects;

(3) establishing a plurality of discrete spatial print path trajectories for each print layer;

(4) establishing a set of printing parameters as a function of the nature of the materials deposited and the deposition conditions thereof for each print layer and for each discrete spatial trajectory;

(5) establishing a spatial and temporal sequencing law for the print path for said print layers and for said discrete spatial trajectories as a function of the objects, their relative three-dimensional arrangement and the characteristics of the printer, in order to optimise the process of depositing each print layer.

2. Method according to claim 1, characterised in that the slicing of the representation of the multi-material composite consists in maximising the quantity of materials deposited per print layer.

3. Method according to either claim 1 or claim 2, characterised in that it consists at least in:

determining a first modulation of discrete spatial print path trajectories for each print layer;

determining at least one predetermined direction of discrete spatial print path trajectory for each print layer;

determining a second modulation of the discrete spatial print path trajectory from a current layer to the following layer for two successive print layers of the same object, said modulation depending on the number of constituent layers to be deposited for said object in order to optimise the cohesion of the final structure of said multi-material component.

4. Production method according to claim 3, characterised in that said first modulation consists in determining a second discrete spatial trajectory by a spatial shift of the ejection step of a first discrete spatial trajectory.

5. Method according to either claim 3 or claim 4, characterised in that said second modulation of the discrete spatial print path trajectory is a modulation of the print path direction defined for each print layer of the object relative to an orthogonal reference frame, each print layer being allocated a specific direction which differs from a preceding print layer to the following print layer of the object.

6. Method according to any one of claims 3, 4 or 5, characterised in that, for a successive ejection of at least one droplet of material at a predetermined ejection step, said second modulation consists of an amplitude and/or spatial shift modulation of said ejection step from a preceding print layer to the following print layer of the object.

7. Production method according to any one of claims 1 to 6, characterised in that the spatial and temporal sequencing law for print path of the print layers and the discrete spatial trajectories comprises a plurality of printing instructions and of successive cleanings of the ejection system.

8. Production method according to any one of claims 1 to 7, characterised in that one of the printing parameters is the ejection distance orthogonal to the deposition surface, said method consisting in regulating said ejection distance around nominal values, the nominal

values being determined so as to optimise the deposition of the materials on the deposition surface.

9. Production method according to any one of claims 1 to 8, characterised in that one of the printing parameters is the size and shape of the ejected material droplets, said method consisting in controlling the size and the shape of each droplet of materials to be ejected, as a function of the nature of the materials, the deposition conditions thereof and predetermined print layer thicknesses.
10. Production method according to any one of claims 1 to 9, characterised in that one of the printing parameters is the temperature of the materials prior to ejection, said method consisting in controlling the temperature of these materials prior to ejection of each droplet, as a function of the nature of these materials and the type of ejection means.
11. Production method according to any one of claims 1 to 10, characterised in that one of the printing parameters is the degree of obstruction of the ejection system, said method consisting in cleaning the ejection system once the degree of obstruction exceeds a predetermined obstruction threshold value.
12. Production method according to any one of claims 1 to 11, characterised in that one of the printing parameters is the storage state of the materials, said method consisting in controlling the material state characteristics by controlling the temperature, controlling the pressure and controlling the state of dispersion of the stored materials as a function of their nature in order to optimise the material storage conditions.
13. Method according to any one of claims 1 to 12, characterised in that one of the printing parameters is the state of the printing environment, said method consisting in controlling the characteristics of the environment in which the multi-material component is produced as a function of the nature of the deposited materials.

14. Method according to any one of claims 1 to 13, characterised in that one of the printing parameters is the power and wavelength of a radiation applied to the deposited materials as a function of the nature of the deposited materials.

15. Device for producing a multi-material component by the ink-jet-type printing of droplets of at least one material in successive layers, characterised in that it comprises:

- independent means (103a, 103b, 103c) for three-dimensional displacement in three reference directions;
- material droplet ejection means (110a, 110b, 111a, 111b) which are integral with the three-dimensional displacement means and are controlled in terms of temperature, pressure and size and shape of ejected droplets;
- means (106a, 106b) for storing and conditioning the materials, adapted to control the temperature, pressure and state of dispersion of the materials and connected to the ejection means (110a, 110b, 111a, 111b);
- a data processing unit (105) comprising at least:
 - a module (198) for computing and determining characteristic objects of a representation of said multi-material component to be produced and of successive print layers on the basis of said characteristic objects;
 - a module (201, 202) for establishing, for each print layer, a plurality of discrete spatial print path trajectories and a spatial and temporal sequencing law for said print layers and said discrete spatial trajectories;
 - a module (202) for establishing a set of printing parameters for each layer and each discrete spatial trajectory; and

- a module (204, 207, 208, 209, 210, 211) for monitored control of said independent three-dimensional displacement means (103a, 103b, 103c), said means (106a, 106b) for storing and conditioning the materials and said material droplet ejection means (110a, 110b, 111a, 111b), in order to optimise production of the multi-material component.

- three-dimensional displacement measuring means (112, 117a, 117b) and printing parameter measuring means, connected to the data processing unit;

- means (210) for synchronising the three-dimensional displacement and ejection of materials as a function of the sequencing law.

16. Production device according to claim 15, characterised in that the module (198) for computing and determining characteristic objects of a representation of said multi-material component to be produced and successive print layers on the basis of said characteristic objects is adapted to maximise the quantity of materials deposited per print layer.

17. Production device according to either claim 15 or claim 16, characterised in that the establishing module (201, 202) is adapted to determine, for each print layer, a first modulation of discrete spatial print path trajectories, means for determining, for each layer, at least one predetermined direction of discrete spatial print path trajectory, and means for determining, for two successive print layers of the same object, a second modulation of the discrete spatial print path trajectory from a current print layer to the following print layer of the object, said modulation depending on the number of constituent print layers to be deposited for said object.

18. Production device according to claim 17, characterised in that the establishing module (201, 202) for determining said first modulation is adapted to determine a second discrete spatial trajectory by a spatial shift of the ejection step of a first discrete spatial trajectory.

19. Production device according to either claim 17 or claim 18, characterised in that the establishing module (201, 202) for determining said second modulation of discrete spatial print path trajectory is capable of determining a modulation of the print path direction,

defined for each print layer of the object relative to an orthogonal reference frame, each print layer being allocated a specific direction which differs from a preceding print layer to the following print layer of the object.

20. Production device according to any one of claims 17 to 19, characterised in that the module (201, 202) for determining said second modulation is capable, for successive ejection of at least one droplet of materials by a given ejection step, of determining an amplitude and/or spatial shift modulation of said ejection step from a preceding print layer to the following layer of the object.

21. Production device according to claim 15, characterised in that the establishing module (201, 202) is adapted to establish a spatial and temporal sequencing law for print path of the print layers and of the discrete print trajectories comprising a plurality of instructions for printing and cleaning the ejection system.

22. Production device according to any one of claims 15 to 21, characterised in that the three-dimensional displacement means (103a, 103b, 103c) are formed by three independent unidirectional displacement plates which are each displaced by a given ejection step, the first (103a) along a first horizontal axis X, the second (103b) along a second horizontal axis Y and the third (103c) along a third vertical axis Z, the axes X, Y and Z defining said orthogonal reference frame.

23. Production device according to claim 22, characterised in that the module (204, 207, 208, 209, 210, 211) for controlling the displacement system is adapted to control the first plate (103a) and the second plate (103b) according to the spatial and temporal sequencing law for print path of the print layers and the spatial trajectories.

24. Production device according to any one of claims 15 to 23, characterised in that the ejection means (110a, 110b, 111a, 111b) are formed by at least one ejection head (110a, 110b) connected to the means (106a, 106b) for storing the materials and by at least one ejection nozzle (111a, 111b) connected to the at least one ejection head (110a, 110b).

25. Production device according to claim 24, characterised in that the ejection means (110a, 110b, 111a, 111b) comprise means (115a, 115b) for controlling the temperature and pressure of the material, which are adapted to control the temperature of the material in each of the at least one ejection heads and to control the pressure of the material in each of the at least one ejection heads.

26. Production device according to claim 25, characterised in that the control module (205, 207, 208, 209, 210, 211) comprises means (210) adapted to control the means (115a, 115b) for controlling the temperature and pressure of the materials as a function of the nature of the material and of the ejection and deposition conditions thereof.

27. Production device according to any one of claims 24 to 26, characterised in that the control module (204, 207, 208, 209, 210, 211) comprises means (209) for controlling the shape and size of the droplets ejected by at least one ejection nozzle (111a, 111b), said control means being adapted to control the shape and size of the droplets by the at least one ejection nozzle (111a, 111b) by transmitting a control signal to the at least one ejection nozzle, said signal being representative of the size and shape of the droplet of materials to be ejected, as a function of the nature of the materials, the deposition conditions thereof and the morphology of the already printed layers.

28. Production device according to any one of claims 24 to 27, characterised in that control module (204, 207, 208, 209, 210, 211) comprises means (208) for controlling one of the plates, adapted to control the distance between the nozzle and deposition surface on the basis of measurement of the distance between the nozzle and the deposition surface, the nature of the materials and the deposition conditions thereof.

29. Production device according to any one of claims 15 to 28, characterised in that the means (106a, 106b) for storing and conditioning the materials comprise means (107a, 107b) for controlling the temperature, pressure and rheological property of the materials, which are adapted to control the characteristics of the stored materials by controlling the temperature, pressure and state of dispersion of the stored materials, and in that the control module (204, 207, 208, 209, 210, 211) comprises control means (211) adapted to control said means (107a,

107b) for controlling the temperature, pressure and state of dispersion as a function of the nature and deposition conditions thereof.

30. Device according to any one of claims 15 to 29, characterised in that the data processing unit (105) is connected to means for acquiring the degree of obstruction of the ejection means and is adapted to trigger a cleaning sequence once the degree of obstruction of the ejection means (110a, 110b, 111a, 111b) measured by the means for acquiring the degree of obstruction exceeds a predetermined obstruction threshold value.

31. Production device according to claim 28, characterised in that the means (117a, 117b) for measuring the distance between the nozzle and the deposition surface comprise at least one laser sensor.

32. Production device according to any one of claims 15 to 31, characterised in that it comprises a production chamber (123) in which the multi-material component is produced, the chamber being adapted to control the characteristics of the printing environment.

33. Production device according to claim 32, characterised in that the chamber (123) is adapted to control the temperature of the environment in which the component is produced.

34. Production device according to any one of claims 15 to 33, characterised in that it comprises a radiation source (130) connected to the data unit (105) and adapted to emit radiation as a function of the nature of the deposited materials.

35. Device according to claim 34, characterised in that the data unit (105) is adapted to control the radiation source (130) in terms of instants of emission, power, wavelength of the radiation emitted by the radiation source (130) to control a change of state of the deposited materials.

36. Production device according to any one of claims 15 to 35, characterised in that the printing parameters are optimised as a function of the nature of the materials and characteristics of the printer, said parameters being stored in a database (199).

37. Device for storing a material for a device for production by ink-jet-type printing, characterised in that it comprises, in the vicinity of a material outlet orifice (302): a system (307) for delivery of this material, the opening of said delivery system being controlled, stirrer means (304, 305, 309), temperature control means (311) and pressure control means (316) for the stored material, in order to optimise the state of the material in the vicinity of the outlet orifice (302) thereof.

38. Storage device according to claim 37, characterised in that the temperature control means (311) are formed by at least one Peltier effect module.

39. Storage device according to either claim 37 or claim 38, characterised in that the stirrer means comprise a motor, an internal shaft of which one end is adjacent to the outlet orifice, and at least one stirrer blade fixed to the end adjacent to the outlet orifice and in that the motor sets the internal shaft into rotation via a magnetic drive system.

40. Ejection head for a material for a device for production by ink-jet-type printing, characterised in that it comprises a material tank (500), means (507, 508, 509, 510) for controlling the temperature of the material stored in said tank, means for controlling the pressure of the material in said tank and means for cleaning the discharge pipe for said material.

41. Ejection head according to claim 40, characterised in that the material temperature control means (507, 508, 509, 510) are formed by at least a heat-extracting ventilation system (510), a heat exchanger system (509), a cooling system (508) and a system (507) for thermal interfacing between the material contained in said tank (500) and the cooling system.

42. Ejection head according to either claim 40 or claim 41, characterised in that the material partially fills said tank and in that the material pressure control means are adapted to control the pressure of the gas in the free portion (512) of the tank.

43. Ejection head according to any one of claims 40 to 42, characterised in that the material discharge pipe cleaning means are formed by a cleaning fluid injection system (503b) at the intake (502) of said tank (500).